KNOW-LEDGE IS POWER

CANADIAN DISTRIBUTORS

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Limited

Gas Engine Department

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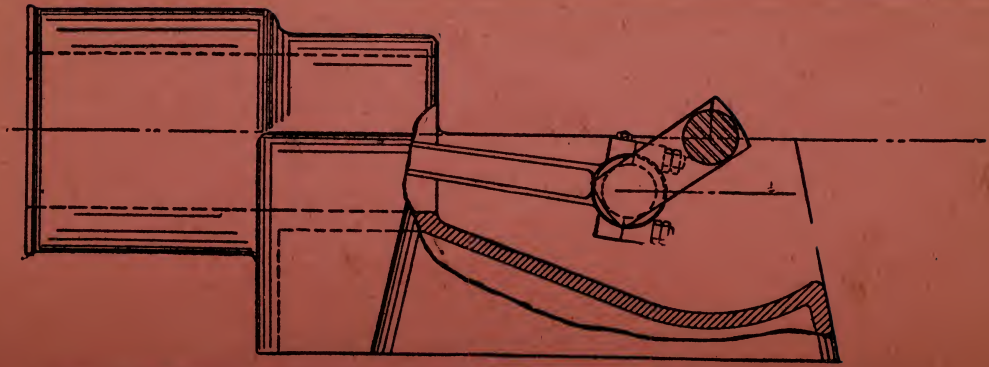
Barrie, Ont.



CUT SHOWING POSITION OF CRANK WHEN IGNITOR SHOULD SPARK.

SUGGESTIONS TO USERS OF GASOLINE ENGINES

1. **INSTALLATION**—Perfect alignment of the Engine with the line shaft or the pulley of the machinery to be driven is of the greatest importance. If the line shaft is already in position, it is well to take the precaution to see that the drive pulley on the engine and the pulley on the line shaft of machinery to be driven are in line before bolting down the engine.

This is done by stretching line from the outer edge of the pulley on the engine to the outer edge of the driven pulley; this line should just touch the edges of each pulley. If satisfactory service is expected from the engine it is absolutely necessary to have perfect alignment.

2. **EXHAUST PIPE** should have as few elbows as possible and should ALWAYS terminate in the open air.

The engine room should have plenty of light and be **kept clean**, as cleanliness contributes greatly to the successful running of an engine.

3. **IN STARTING THE ENGINE** if it fails to ignite its first, second or third charges, the cause of non-ignition will not be removed by turning the wheels and will probably be getting worse the longer you turn.

4. If the engine does not ignite its first charges there is a cause for it and **no amount of turning will locate it**; this requires a little common sense which will not only locate, but remove the cause.

5. If the engine is receiving its fuel in proper proportion and the ignitor is working all right, it

will go right up to its normal speed within a few seconds after starting, and if it is taking only one charge in three or four revolutions and firing every charge it takes, you may know it is ready for work.

6. But if there is popping and back-firing in the receiving pipe, it may need more fuel, or the receiving valve may not close properly, or the ignitor may not be set in proper time, or is otherwise out of adjustment.

7. Too much fuel is indicated by smoke issuing from the exhaust pipe, as the charges that are taken are not all ignited. **You can shut down** a gas engine by feeding it **too much fuel** just as easily as by not giving it enough.

It is a mistake to turn on more fuel when more power is wanted.

When an engine is pulling nearly its full load it should "cut out" one charge every six or eight revolutions.

8. **COMPRESSION** has very much to do with the **power developed;** for instance, if the valves are not seated properly, or if the piston rings are worn so as to allow the escape of part of the charge, there will be a **great loss of power.**

9. Just before expansion occurs in the gas engine cylinder, compression of the charge is necessary. All gasoline engine cylinders have a compression space. It is that part of the cylinder space which is behind the piston when the piston is on the inner dead centre. The compression space is usually about 30 per cent. of the entire cylinder volume, the cylinder volume is known as all that space behind the piston which is unoccupied when the piston is on the outer center. We will take, for instance, a cylinder that has one cubic foot of space within it when the piston is at the extreme point of its outward stroke. One cubic foot is equal to 1728 cubic inches. When the piston travels from its outer to its

inner center it takes up or occupies 70 per cent. of this 1,728 cubic inches of space and leaves 30 per cent. of it unoccupied. By the inward stroke of the piston the cylinder space is reduced from 1728 cubic inches to 518 cubic inches. When the outward stroke of the piston draws in a charge of air or gas, and when it reaches its outer center there are, practically speaking, 1,728 cubic inches of the air and gas mixture within the cylinder. On the following inward stroke of the piston this explosive mixture of air and gas is crowded into 578 cubic inches of space. Now, if 1,728 cubic inches of air at atmospheric pressure is crowded into a space of only 518 cubic inches of space, the pressure will be very greatly increased.

10. When a gasoline engine is **weak in power and does not start readily,** it is well to turn the wheels over slowly by hand and notice the proportion of resistance when the piston is on its compression stroke. The cushion of the compressed charge should be great enough to rebound the piston like a rubber ball when you let go of the wheel at the highest compression point. When compression is good, and as it should be, it is a difficult matter to turn the wheels slowly over the compression point, and for this reason nearly all gas engine manufacturers provide some means of relief, such as a pet cock, which is intended to be opened when the engine is turned over by hand for starting purposes, or a relief cam and roller.

11. The charge once ignited the combustion is more rapid, that is, the flame spreads more quickly over the entire charge because of the crowded condition of the combustible particles. An explosion of any kind is nothing but a quick burning of the material consumed. All explosions are not alike in the time it takes to consume the exploded material. The slower the process of burning the lighter is the explosion and expansion. But the quicker the

explosive is consumed the higher degree of heat and the heavier the resulting expansion. We may get the same quantity of heat from a certain charge by burning it slowly as if burnt quickly, but by distributing the same heat through a greater length of time, the degree is less intense by reason of greater time allowed for cooling.

12. The object, then, of compression in the gas engine is to get a **vigorous, quick and rapid explosion** from the gas consumed, which results in the highest degree of heat and heaviest expansion that can be attained. **This imparts powerful impulses** to the piston, and the engine runs with a vim and shows powerful energy. On the other hand, **if compression is low,** the mixture burns slowly, the engine runs in a slovenly manner, is lazy and **does not develop the power** it should. The same quantity of fuel is consumed in doing about half the work. Hence the importance of compression. After knowing its importance one should frequently test it and watch closely the valves, piston, rings, etc., to see that there is no leak from the cylinder while the piston is on its compression stroke.

13. **THE TIMING OF THE VALVES** is of the utmost importance, and to get proper results the movement of the valves should be properly timed.

14. You can test an engine to know if it is properly timed by turning the wheels very slowly and noticing at what point the valves open and close, and where the ignitor points separate.

15. The Intake or Suction Valve should open at the beginning of the outward stroke and close at the end of the same stroke.

The next inward stroke is the Compression stroke when all valves should be closed.

16. The function of the **EXHAUST VALVE** is, at a predetermined moment, to open and allow the gases which have been used to escape, in order that

the cylinder may take in a fresh explosive charge.

The valve, as shown in the diagram, has what is called a mitre face. When closed down as in Fig 1, it fits tight down on to a mitre seating, is held down by a spring, and forms a gas-tight joint.

When it is required to let the exploded charge escape, the valve is pushed open by a cam or lever, and the hot gases, still burning, rapidly escape into the exhaust pipe in the direction shown by the arrows in Fig. 2.

Owing to the frequency of the explosion, and the fact that the gases are very hot when they pass over the face of the valve and its seat, both become burnt, and a scale forms on the surfaces.

This scale in time chips away, and the perfect fit of the valve is spoiled. The result is that leakage takes place and the full charge is not available for the explosion.

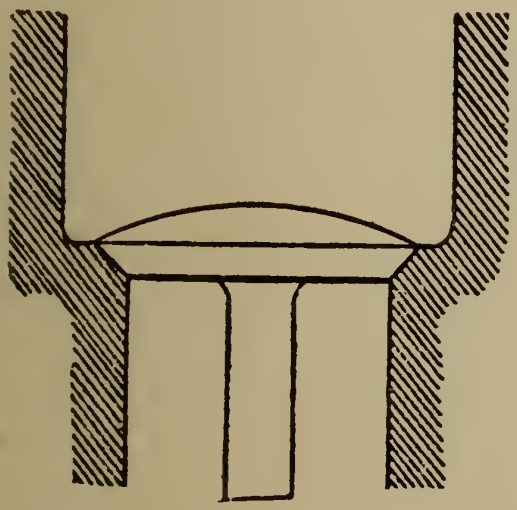


FIG. 1—The valve is in the closed position. The mitre-faces fit firmly together, and form a gas-tight joint.

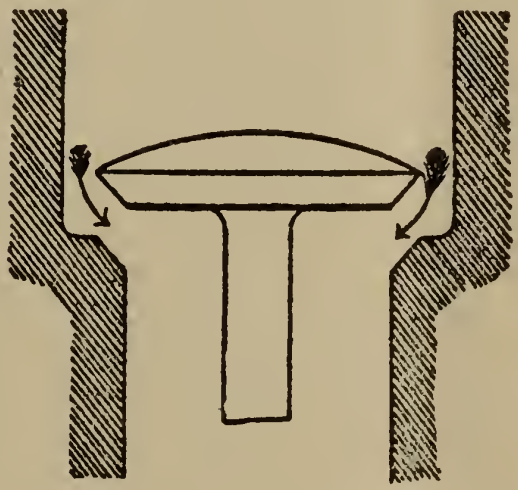


FIG. 2—In this position the valve has been lifted by a cam, or lever, and the exhaust gases pass out in the direction of the arrows.

To make the valve tight again it is necessary to grind the pitted surface until it becomes smooth.

17. **The Exhaust Valve Spring** may become so weak that it will not keep the exhaust valve closed firmly to its seat, and in some types of engines the

suction or intake valve is not provided with a "locking lever," therefore it is very necessary that the intake valve spring, on such engines especially, should be sufficiently strong to keep this valve closed when the exhaust is open, otherwise a certain amount of gasoline will be sucked into the cylinder and discharged through the exhaust, resulting in a waste of fuel. Remember, **the intake or suction valve, should never open** except **when exhaust valve is closed.** If either of the above springs are weak, don't lose any time in putting in new ones or stretch the old springs so that when they are put back on, these valves will be held firmly to their seats.

18. **The Suction Valve Spring** may be made too strong, thus interfering with the easy opening of this valve by suction. It should be tight enough to hold when the exhaust valve opens, at the same time allow the suction valve to open freely when the exhaust valve is closed.

19. **HOW TO GRIND A VALVE**—When it is suspected that a valve needs grinding, strip the stem of its lock-nuts and spring, and remove the cap or plug, over the valve pallet, lift it out and examine the seat.

If it does not show a good bright bearing all around **it needs grinding,** which is done as follows: Apply lubricating oil to the seat of the pallet, then sprinkle on some flour of emery and drop the pallet into its seat.

With a brace and bit the pallet may be turned round and round for a time and then back and forth in a semi-circle. Work it this way, **alternating the movements,** for some time. Occasionally lift the valve pallet slightly from its seat, let it drop back and repeat the grinding movements.

When the valve turns without any apparent grinding friction take it out, wipe it clean, examine

the seat, apply more oil and emery, and put it through another course of grinding.

This process may have to be repeated a number of times, but do not get in too much of a hurry to get through.

Two hours spent industriously on a valve may prove to be well spent and time saved.

When a good bearing seat is secured, wipe the valve pallet and stem, as well as the valve seat and sleeve in which the stem works, entirely free from emery, oil and grit. Return the pallet to its seat. close up the valve and adjust the spring and lock-nuts to the stem ready for service.

20. **Poor Lubrication** of the cylinder is often indicated by peculiar blowing noise in the cylinder at each impulse. It is due usually to a dry piston allowing the force of combustion to pass the rings. It can often be overcome by adjusting so that the oil will flow freer. After running a cylinder dry, at the first opportunity the piston should be taken out and the rings, grooves and entire piston thoroughly cleaned.

21. **If Water from the Hydrant** is forced around a cylinder so as to keep it cold, the heat from the explosion or combustion is cooled down so quickly by radiation that the expansion force is materially reduced, and consequently less power derived from the same charge.

22. The object of the water is **not** to **keep the cylinder cold,** but simply cool enough so as to prevent the lubricating oil from burning. **The hotter the cylinder** with effective lubrication the **more power the Engine will develop.**

The temperature of the water after it has passed through water-jacket should be about 160 degrees.

23. **DEFECTIVE IGNITION**—The symptoms and causes for defective ignition are numerous, but below are a few of the most common.

Difficult starting, thumping in the cylinder, and occasional loud report at the end of the exhaust pipe, miss-firing and premature firing. When an engine refuses to start after turning the wheels several times, the chances are something is wrong with the ignition, and the igniting apparatus should be examined. **The switch may be disconnected.** Some of the **wires may be loose** on their binding posts. **The movable electrode may be gummed or corroded.** The ignitor points may need renewing or cleaning. The **battery may be nearly exhausted** and needs renewing, or the current may be short-circuited somewhere before reaching the engine.

24. When electric ignition is used, the timing of the spark is most important. **The ignitor should trip** and the electrodes separate and make a spark **just before the end of the compression stroke** is reached, which is **just before** the **crank reaches** the **inner center.** This is to allow for the instant of time between making of the spark and the resulting combustion. The force of the combustion does not come simultaneous with the making of the spark. Therefore, the compression stroke will have ended before the force of combustion really begins, and if the spark is made just at the end of the compression stroke, actual ignition or expansion will not occur until the piston has travelled probably one-fourth of its outward stroke. Consequently it is necessary that the **spark should be made before the piston reaches the inner center.** Care must be taken not to adjust the ignitor so that the spark is made **too early,** as expansion of the charge ignited would occur before the piston reaches the end of the compression stroke, resulting in the engine "working against itself."

25. The tendency of this would be to reverse the engine, but the momentum of the fly-wheels carries the piston on even against the enoumous pressure. Of course, the power of the engine is decreased, because the efficiency of the engine is greatly decreased in overcoming the tendency to reverse. But if early ignition continues for any length of time it will eventually partially or totally wreck the engine. As has been explained, at the time of the early ignition the crank-shaft is below dead center, and the engine would naturally tend to reverse. This does not occur, from the fact that the momentum of the fly-wheel carries it on. However, there is a very heavy strain on the crank shaft, since the piston and connecting rod are forcing it in one direction, while the fly-wheels are forcing it in the opposite. This strain, if kept up for any length of time, starts a small check or crank at the junction of the crank-cheek with the journal. This crack gradually works all around the shaft and into the cheek at an angle of about 45 degrees, or, rather, in a curved line. Finally there is so little stock left that this suddenly breakes and leaves the cheek with a cup-shaped depression into which the broken end of the shaft fits. As the crack gradually works in farther and farther, the vibration rubs the broken parts smooth and oil follows in. When the final break does occur, this oily and smooth surface has the appearnce of an old break or a flaw, while the small portion of the fracture which broke last is the only part which shows a fresh, rough break. This creates a wrong impression in the mind of the owner of the engine, who at once jumps at the conclusion that, since the break has undoubtedly been of long duration, and as it shows a smooth surface over the larger portion of the fracture, the shaft must have been welded into the cheek and the weld imperfectly done. Accordingly, he demands of the manufacturers a new shaft free of

charge, as well as that the rest of the engine, which may have been damaged more or less, be repaired without cost to him.

26. An engine with an electric ignitor operates the igniting mechanism, while the crank is at a certain point below the dead inner centre as has been previously explained. When the engine is new and before any parts get out of adjustment it is well to make a mark in some way to show the position of the crank shaft when the ignitor trips. By having some guide to go by it enables the operator to tell at any time, whether the engine is igniting at the proper time.

27. As to the causes for early or late ignition. First, the engine may be out of adjustment. All igniting mechanisms wear in time and require some adjustment. Sometimes they are changed accidentally by some person taking off a part of the engine and not putting it back correctly, often a side shaft is removed and when put back the gears are not meshed with the same teeth together again. A difference of only one tooth will throw the whole engine out of time. Or the points may wear gradually and by so doing change the time of ignition. All engines have parts which gradually wear and the ignitor points are sometimes not noticed by the operator. Many people who have had a crankshaft broken through early ignition will tell the manufacturer that the time of ignition has never been changed since they got the engine. They seem to think that since nothing has been done to the engine the time of ignition must be the same as when it was new. The statement that they have not adjusted their engine shows that it cannot be in the same conditoin as when shipped, as more or less wear has taken place and changed it.

28. **SHORT CIRCUIT**—If one wire from the battery to the engine should have its insulation

broken at a point where it touches some pipe or iron that in any way communicates with the other wire it results in an external short circuit. Broken insulation may short circuit the spark oil.

29. **The battery current is tested** by disconnecting the end of one of the wires and touching with it the binding post to which the other wire is attached. If it does not make a bright spark every time the wire is snapped or slipped off the binding post, you can be sure that some of the causes above named are to be found, and as soon as the causes above named are removed the spark will show up all right.

30. If there is a good spark on the ends of the wires, and a weak one or none at all at the point of contact of the electrodes it indicates that the trouble is in the sparking mechanism of the engine. This means the mechanism is either corroded, gummed up, or short circuited.

31. **The sparker insulation** can easily be tested by disconnecting the wire not attached to the insulated electrode, and snapping it on some bright part of the engine, when the electrodes are apart (the other wire being, of course, attached to the binding post or the insulated electrode), and if a spark is made it indicates that the insulation is broken, and consequently short circuited. If no spark is made the insulation is all right.

32. Either a good fluid or dry cell battery will furnish a good spark from two to six months, according to the amount of work done by the engine. If the engine is used continuously for ten hours each day, the battery may have to be renewed any time after two months.

33. IF THE SWITCH IS NOT TURNED OFF WHEN THE ENGINE IS NOT IN OPERATION, OR LEFT TURNED ON OVER NIGHT, THE RESULT

MAY BE A COMPLETELY EXHAUSTED BATTERY BY MORNING.

34. The character or appearance of the spark, and especially if it is of a scattering nature, should lead you to suspect a short circuited spark coil. An effective or good igniting spark is a **SINGLE BLUE-WHITE SPARK** at the point of contact. But beware of a dozen little sparks from the terminals. They will not ignite.

A battery may not be entirely exhausted when it fails to give an igniting spark, and the spark from such a battery may not be of sufficient intensity to ignite the charge in the cylinder.

It is Poor Economy to attempt to run on weak batteries, you can't do it successfully.

35. The sure **signs of a weak battery** are, difficult starting, miss firing, and the final dying down of the engine.

An engine may run a few hours on a weak battery, and then quit, and no amount of coaxing will get it started again that day.

Perhaps the next day it will repeat the performance. The reason it can be started the next day and not immediately after it has stopped the day before, is that during the interval the batteries have sufficiently recuperated to run the engine a short while

Remember, then, that when your engine runs a few hours one morning and stops, and runs a few hours the next morning and stops, **your batteries are too weak** for continuous running.

A bottle holds so many drops of water and if allowed to drip out drop by drop the water will last a given length of time, but if left so there is a continuous stream the bottle will soon be emptied; just so a battery may be said to contain a certain

number of sparks, which if judiciously handled will last so long, but if the switch is left on when the engine is not running the result must be a depleted battery in a few hours.

36. **POUND IN THE CLYINDER**—PREMATURE IGNITION. The principal cause of pounding in the cylinder is premature ignition of the charge. Premature ignition is usually caused by some projecting point of iron or carbon deposit in the cylinder that becomes red hot, which seems to ignate the charge prematurely.

Little chunks of burnt carbon, accumulating from the burnt cylinder oil in the combustion chamber, may constantly remain heated to the ignition point and ignite the charges prematurely. It is, therefore, necessary to occasionally clean out the gas engine cylinder.

If pre-ignition is the cause, the pounding will cease as soon as the combustion chamber is cleared of the carbon deposit, and the heated projecting point causing the firing is removed.

37. An improperly proportioned mixture, resulting in a slow combuston, may be so slow as to be still burning when the next charge is admitted, and then the new charge will be ignited just as it is entering the cylinder and fire back through the receiving pipe.

38. A knock or pound at the wrist or crosshead, due to lost motion must not be taken for a pound in the cylinder. A loose fly-wheel makes a thump which very much resembles the sound like a thump in the cylinder.

39. To test pre-ignition cut off the electric current by throwing the switch, and if the engine continues to fire its own charges and runs along pounding away it is good evidence that the pound

is due to pre-ignition. If, however, it ceases to fire charges the instant the igniting current is cut off, pre-ignition caused by projecting points or carbon deposit may be excluded. If the pounding keeps up after the engine stops, a tight piston is probably the cause of the trouble.

40. If a piston is made to fit the cylinder snugly it will usually result in pounding in the cylinder when the engine is put under a heavy load. The cylinder thump or pound is a deep heavy pound, while a loose fly-wheel or loose wrist bearing is indicated by more of a clicking variety.

41. Then there is a barking noise due to the escape of the **EXPLOSIVE FORCE PAST THE CYLINDER RINGS.** This is easily distinguished from the other.

42. If the cylinder rings allow the explosion to pass, making a barking noise, they should be replaced by new ones well fitted into their grooves, and fitted to the cylinder so as to bear at all points of their circumference on the cylinder wall.

If the knock is in the cross-head it may be removed by tightening up the bearing.

43. Don't conclude that a **THUMP, POUND** or **THUD** about an engine is always due to some trouble in the cylinder. Look for such causes as the following:

First—Pre-ignition (premature firing).

Second—Badly worn or broken piston rings.

Third—The explosive force escaping by the piston

Fourth—Improper seating of a valve.

Fifth—A badly worn piston.

Sixth—Piston striking some projecting point or foreign body in the combustion chamber.

Seventh—A loose crosshead bearing.

Eighth—A loose crank or wrist bearing.

Ninth—A loose nut on journal box cap.

Tenth—A fly-wheel or pulley loose on the shaft.

Eleventh—Lost motion in any bearing, gear or governor.

The sound produced by pre-ignition may be described as a **DEEP, HEAVY POUND.**

A loose fly-wheel causes a thump, or sometimes a sort of metallic grating sound.

A loose cross-head or crank bearing makes a thud or knock.

A click will usually direct attention to a loose nut or cracked rim, spoke or hub, on pulley or fly-wheel.

44. **LOSS OF POWER**—The loss of power is due principally to **leaky valves, miss-firing** and **choked inlet or exhaust passage.** A bent exhause lever or lost motion by reason of a worn condition of the cam and cam-wheel or roller, which will prevent a full and free opening of the valve, will cause a constricted passage.

45. Under leaky valves may be considered leaky piston rings, or any point about the cylinder where part of the explosive force escapes while it is driving the piston on its working stroke.

The valves, if leaking, should be taken out and thoroughly cleaned and ground into their seats with powdered emery and lubricating oil.

46. If the cylinder rings are worn so as to become leaky or allow escape of the explosive force, they must be replaced by new ones, and it is sometimes necessary to put the piston into a lathe and true up the grooves to fit new rings. If any point of leak is discovered it should be properly packed or plugged at once.

47. **MISS-FIRING** means failing to fire each charge the engine takes, and the remedy has already been given. It consists of examining the battery and all its connections to the electrodes, and determining whether the battery is exhausted or not; whether there are broken connections; whether the electrodes or other points need cleaning, or attention otherwise. If tube ignition is used; whether the tube is hot enough; whether it is heated too high up; whether by corrosion or other means the passage from the cylinder to the inside of tube is closed up. Also determine whether fuel is fed to the engine in proper quantities.

48. **CHOKED INLET PASSAGE**--Nearly all gas engines are fitted with some kind of mixing device in the shape of a perforated plate, wire screen, etc. These mixing devices may become occluded by deposits of dust, soot, waste, cloth or paper drawn into the inlet pipe. The strangest of all is that they sometimes become occluded with ice. The rapid vaporization of the gasoline while passing through the mixer may freeze any water elements in the air and gasoline, and deposit it in the shape of ice in the mixer until it becomes completely occluded. The engine may start off and pull its load easily, and as the ice is gradually deposited in the mixer the engine shows less and less power, until it finally stops. A wait of five or ten minutes will melt the ice sufficiently to allow another short run. Such actions or symptoms should lead one to suspect a frozen up mixer and to look for the cause.

49. **BACK-FIRING**—The explosive force coming out of the mouth of the receiving pipe is called back-firing. Its principal cause is a delayed combustion of the previous charge. When the air entering the cylinder does not receive a sufficient charge of gas or gasoline it makes a slow burning mixture. This mixture may be so slow in combustion

that it continues to burn not only on the working stroke but also on the exhaust stroke of the piston, and there still remains enough flame in the cylinder to fire the fresh incoming charge, which of course escapes back through the receiving pipe, the receiving valve being open.

Any projecting point of iron in the igniting chamber or chunks of carbon deposited in the cylinder may become heated to a red heat and serve to ignite the incoming charges.

Feeding the fuel a little more freely will remedy the back-firing if caused by a weak mixture. If this does not control it, chunks of carbon or projecting points of iron or carbon should be looked for and removed if found.

50. **OBSTINATE STARTING**—Defective ignition is one of the principal causes, and you have already been told the remedy. But **SLOW VAPORIZATION** of gasoline in cold water, **OVERCHARGING THE INGOING AIR** with gas or gasoline when turning an engine over by hand, and **WATER IN THE CYLINDER** when trying to start, are causes as frequently met with as Defective Ignition.

You can facilitate vaporization of gasoline in cold weather for starting purposes by previously heating some point of the air pipe, which serves to warm the air as it enters, which in turn vaporizes the gasoline better than cold air.

A bottle of gasoline heated by holding it in hot water may be used for starting. The heated gasoline vaporizes easier.

51. If **WATER** is found in the cylinder it must be removed and the leak stopped before a start is made. Sometimes a leak is so slight that it will not affect the running of the engine after it

has started, but will leak enough while the engine is idle to prevent starting.

Therefore it is always well to drain the water jacket entirely before stopping the engine, and to start the engine before turning the water on again. Forming a habit of thus draining the water off before stopping the engine will serve an excellent purpose both in a leaky cylinder and in cold weather, by avoiding any chance of freezing.

52. **WEAK EXPLOSIONS** when engine is starting, hardly strong enough to drive engine up to speed, indicate leaky valves.

53. **IF SPEED GETS LOWER AND ENGINE FINALLY STOPS,** suspect:

First—Irregular ignition; charges not all fired.

Second—Overheated cylinder or piston.

Third—Hot journal or wrist box.

Fourth—Overload on engine.

Fifth—Fuel supply exhausted.

Sixth—Exhaust or receiving valve leaking.

REMEDIES.

First—Repair broken wire connections, clean electrodes or igniting mechanism, repair insulation, renew battery, attend to magneto or sparking dynamo, heat igniting tube to a higher degree.

Second—Increase supply of cold water and lubricating oil.

Third—Stop engine, examine hot box; if cut any, dress all rough places, and wipe out all fillings or cuttings, re-adjust boxes to bearings carefully, lubricate well, start engine, and keep a close watch on it for several days. If it shows any tendency to heat, examine again and re-adjust.

Fourth—Reduce load on engine.

Fifth—Replenish fuel supply.

Sixth—Grind the valve that leaks to a good seat with emery flour and oil. Leaky valves and piston rings can be tested by turning the engine wheels over till the piston goes on its compression stroke. If the valves and piston hold, the compression of air causes the piston to rebound. If they leak, you can turn the wheel over on the compression stroke.

54. **SMOKE** at the end of the exhaust pipe means an over supply of fuel or a surplus of lubricating oil in the cylinder.

Set needle valve closer so as to feed less gasoline or gas. If this does not stop the smoke, feed less lubricating oil into the cylinder.

55. **SMOKE** at open end of cylinder indicates either that there is a sand hole in the piston, leaky rings, or that the lubricating oil in the cylinder is decomposed by the heat.

Piston taken out and filled full of water will test it for a sand hole or other leak.

When the piston is out examine rings, if broken or worn out, or show by wearing at only one or two places in their circumference that they do not fit the cylinder, replace them with new ones snugly fitted into the piston grooves, as well as turned to fit the cylinder. If lubricating oil is burning, increase supply of cold water.

56. **BOUND BOXES**—When either the crosshead or wrist boxes become worn so that they shoulder tightly after all the liners are taken out without correcting the lost motion or knock, their shoulders must be either dressed in a shaper by a machinist or filed true so that they can be set snugly to the pin they enclose and yet do not shoulder by from one-eighth to a thirty-second of an inch.

57. **LINERS**—The space between the box shoulders is usually filled in with two to four sheets of cardboard or wood fiber, called **LINERS.**

58. **LINERS REMOVED**—As the boxes wear, one liner at a time is removed and the nuts on the boxes are set up a little closer.

59. **SETTING A BOX.**—Never set a box so close as to bind a pin or shaft it encloses. But set it close enough to prevent knocking. Set the nuts, holding the box, up equally. Bring them up gradually together. Never set one up tight before bringing the others up. Don't be in a hurry. Don't set the boxes haphazard. Try the box after setting by turning the wheels over to see if it works stiff and tight. If so, it is too tight. Use judgment, otherwise you will have a ruined box.

60. **HOT BOXES**—Watch all the bearings on your engine closely, especially when new. If any of them run hot stop your engine and examine carefully for the cause. If too tight loosen it up a little. If it bears heavy on one side dress the point carefully where it shows the most wear; if there is a burr or high point on the shaft or pin dress it down smooth, but don't let the box run hot very long at a time.

61. **BROKEN CRANK SHAFTS — CAUSE LOOSE BOXES**—Broken crank shafts would be a very uncommon thing if the journal boxes and wrist boxes were more carefully looked after and kept properly adjusted. The intent of a box or a number of boxes carrying a revolving shaft is to keep the shaft in perfect line at all times. A box cannot accomplish its purpose on a gas engine if it is not carefully and snugly adjusted all of the time. The sudden force applied to the piston of the gas engine and through it and the connecting rod to the crank shaft tends to lift the shaft out of its journal box

bed at each impulse, even with the weight of the heavy fly-wheels crowding it constantly downward into its bed. If the boxes are snugly fitted, this lifting motion cannot occur. But, on the other hand, if the box caps are loose, each impulse raises the shaft and wheels, and as soon as the force of the impulse subsides the weight of the wheels and shaft bring it down into its bed again with a thump.

This continued heavy strain at regular intervals soon causes what is known as a crystallized condition of the metal in that part of the shaft where the greater strains occur.

The crystallizing of the metal destroys the tensile strength of it, and it becomes fragile. Usually this crystallized condition begins at a point on the outer circumference of the shaft and travels toward the centre. It does not necessarily—and in fact not generally—affect the entire circumference. A third or half of the circumference only is the rule. At this fragile point a crack is started by reason of the continued jumping of the shaft in its bearings. As the crystallized condition grows the crack goes deeper until finally the good metal remaining is no longer able to withstand the strain and breaks in two. When the broken ends are now examined, the fresh break shows only so far as the good or adhesive metal held on. The original crack may have been started weeks or months before, and the constant motion caused the broken parts to rub together until they often appear as if they had never been united.

62. **LIME DEPOSIT IN WATER CHAMBER**—Don't let water chamber become filled with lime deposit. Better clean it once a month by taking off Cylinder Head and scraping the jacket free from lime. If you are called on to clean a jacket that is well filled with lime and difficult to remove by

scraping, the Hot Oil process of removing the lime is, we think, the least injurious.

It is done as follows: Drain all the water from the jacket and through a short nipple of pipe in the upper port fill the water space with oil. Then let it stand over night to cool. Heat it again to the boiling point, next morning by running the engine. Then stop the engine, drain off the oil and let the engine cool off. Then start your engine with water turned on and run for several hours, and when cool shut off water and thoroughly drain off all sediment.

63. **FUEL SUPPLY**—One of the troubles frequently met with is the difficulty in keeping a proper supply of gasoline up to the engine, which may be due to one of several causes. **Dirt or sediment** may have gotten **into the check valves** preventing them from seating properly, which would allow the gasoline to flow back to the tank; the suction or supply pipe may have a leak in it. When this pipe is connected up it should be tested thoroughly to see there are **no air leaks** in it, for if bubbles of air work into the pipe they will cause the pump to lose its priming.

The joints of the pipe should always be put together with common **laundry soap**, not with white or red lead.

It is possible the pump needs repacking. **Water in the gasoline**, although sometimes difficult to detect, is another trouble maker. If pure gasoline is spattered with the finger on a piece of metal it will spread out smoothly all over it, but if there is water in it there will be little globules that run around very much like quicksilver does when spattered on anything. Take some pure gasoline and try it and you will see the difference.

Often the check valves in the gasoline pipe are taken out and when put back are **put in backwards.**

Care should also be taken to see that these check valves are put in **straight up and down.**

It sometimes becomes necessary to disconnect the gasoline pipe and clean it out as there is a certain amount of sediment in gasoline, which if not removed by straining the gasoline when filling the tanks, will collect at some elbow or low point in the pipe resulting in hindering the free flow of the gasoline.

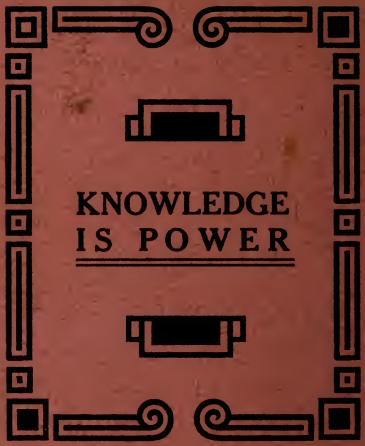
64. **BURSTED WATER JACKET BY FREEZING**—Every fall, about the time of the first heavy frost or light freeze, the manufacturers of gasoline engines receive letters from their customers in various parts of the country reporting bursted cylinder jackets, and it is surprising how many of them will claim a "flaw or defect" in casting, or say that "the cylinder has been leaking at this point ever since they purchased the engine." It is quite plain to the manufacturer, if he can get a minute description of the crack, that it is always the result of a freeze-up due to carelessness on the part of the owner.

The water around the cylinder is usually only a very thin sheet between two iron walls. Iron gives off heat very rapidly, and returns to the temperature of the surrounding atmosphere very quickly, even after being heated red hot, and if the temperature is at or below the freezing point the thin sheet of water between the two iron walls can do nothing but freeze as soon as it reaches the freezing point. This may happen even when no ice is noticeable on the pools out in the open. A pail of water, and especially a bulk of water in a wooden pail or barrel, may not show a trace of ice at a temperature when the **water in the cylinder jacket would freeze,** because water in bulk will retain heat longer than when in a thin sheet, wood will hold heat longer than iron.

It is a rare thing that a freeze-up will cause the cylinder proper to crack, and consequently there is no damage to the interior of the cylinder. In fact the owner of the engine, if he has the proper tools, can put on a patch that will answer the purpose. A small sized drill for drilling a row of little holes on each side of the crack about an inch from it, and a tap to thread these holes, some round or flat-headed screws to fit, a sheet iron plate, a screw driver, a hammer, some asbestos, a little white lead and a cold chisel are the articles and tools necessary.

First, cut a "V" shaped crease with the cold chisel along the crack from one end to the other. Then shape the sheet iron plate so that it will cover the entire crack and extend about one inch on each side of the crack and an inch beyond each end, and dent it so that it will fit the outer surfaec of the cylinder. Now drill a row of small holes large enough to admit the screws about an inch apart all around the edge of the plate, then place it directly over the crack and drill corresponding holes in the jacket or cylinder wall, a size smaller than those in the plate, and thread them with a tap.

Now put some white lead paste in the "V" shaped crease over the crack and saturate some of the asbestos wick, just a small strand of it, with white lead and place it directly over the crease the entire length and a little beyond the ends of the crack. Cut a sheet of asbestos the size of the plate inside of the holes and place this, first soaked in salt water, over the wick and crease and fasten the plate firmly down on to it with the screws. Before doing this, however, all the paint should be scraped off the cylinder to the full size of the patch. After putting on the patch in this manner it may be dressed smooth with a file and let stand a day or two before using the engine. As a rule this makes a very effective and satisfactory repair.



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